

**Lifting Apparatus**

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[1] The invention relates to a lifting apparatus in accordance with the preamble to claim 1.

[2] Lifting apparatuses of this type are used for transporting containers, in particular in port facilities.

[3] These lifting apparatuses called spreaders comprise a stationary main frame with two shuttle booms guided therein. The shuttle booms respectively start at one exit opening on one longitudinal end of the main frame and can be displaced in longitudinal direction of this frame.

[4] Holders for attaching the respective container are located at the free longitudinal ends of the shuttle boom. Each free end of the shuttle boom is provided with a separate headpiece. A locking pin that respectively forms a holder is located at the two ends of the headpiece that project on the side over the shuttle boom. These locking pins are used for attaching the lifting apparatus to the container.

[5] Corner guides are provided as additional holders for positioning the lifting apparatus on the container. The corner guides are located immediately adjacent to the locking pins.

[6] With known lifting apparatuses, hydraulic drives are used to realize the displacement movement of the shuttle boom within the main frame. A hydraulic drive of this type comprises at least one hydraulic motor with a hydraulic pump. Power is transmitted via steel chain links from the hydraulic motor to a shuttle boom.

[7] During the displacement movement, the shuttle boom made of steel is guided with its back end inside the main frame, wherein a lubricating grease cushion is provided between the walls of the main frame and the shuttle boom to reduce the sliding friction between the contacting surfaces.

[8] The holders, in particular the locking pins, are also driven hydraulically. The corner guides can optionally be connected rigidly to the respective headpiece.

[9] Lifting apparatuses of this type have the disadvantage of a high-energy requirement for operating the movable units, especially the shuttle booms. In particular, this is due to the fact that energy must be supplied continuously to the hydraulic drives, even if the units are not moved.

[10] The high-energy requirement also results from the high inherent weight of the shuttle booms, thus resulting in considerable sliding friction forces effective between shuttle boom and main frame.

[11] Another disadvantage of lifting apparatus of this type is that leaks frequently occur in the hydraulic system during the operation. In addition, the grease for the lubricant bolster between shuttle booms and main frame is unavoidably pushed out of the lifting apparatus. This causes considerable soiling of the lifting apparatus and the containers to be transported, which results in an undesirably high expenditure for cleaning and maintenance operations. Furthermore, the hydraulic system leaks require a considerable expenditure for maintenance operations. Finally, the high amount of grease and oil escaping at the lifting apparatus results in high environmental impact.









For this, elements of the shuttle boom that are subjected to tensile loads are primarily made from glass-fiber materials while elements of the shuttle boom that are subjected to pressure loads are primarily constructed from carbon-fiber compound materials.

[33] Another advantageous embodiment of the invention provides for springs in the form of spring leaves for positioning the rollers.

[34] This type of spring support efficiently absorbs any stresses that occur, particularly impact stresses, and also protects the rollers against damage.

[35] The invention is explained in the following with the aid of the drawings. Shown are in:

- Figure 1      A view from above of a lifting apparatus with two shuttle booms guided inside a main frame.
- Figure 2      A view from the side of the lifting apparatus according to Figure 1.
- Figure 3      A cross section through the lifting apparatus according to Figure 1, with the crossbeams for the shuttle booms extending inside slide-in compartments.
- Figure 4      A perspective view of a crossbeam for a shuttle boom that is guided inside a slide-in compartment.
- Figure 5      A cross section through a headpiece attached to a free end of a shuttle boom.
- Figure 6      A schematic representation of two locking pins, arranged on a headpiece and operated with an electric drive.
- Figure 7      An exemplary embodiment of a locking pin according to Figure 6.

- Figure 8 A schematic representation of a corner guide, operated with the aid of an electric drive.
- Figure 9 A view from above of a lifting apparatus with displaceable positioned shuttle booms that are operated with linear drives.
- Figure 10 A cross section through a first lifting apparatus according to Figure 9.
- Figure 11 A cross section through a second lifting apparatus according to Figure 9.
- Figure 12 A view from above of a lifting apparatus with displaceable positioned shuttle booms that are operated with drum motors.
- Figure 13 A cross section through the lifting apparatus according to Figure 12.
- Figure 14 A view from the side of a shuttle boom with lattice-type construction.
- Figure 15 A spring system for a roller for guiding a shuttle boom.

[36] Figures 1 – 8 show embodiments of the lifting apparatus, which were originally disclosed in the DE 101 01 986.

[37] Figure 1 shows an exemplary embodiment of a lifting apparatus 1 for transporting containers that are not shown herein.

[38] The lifting apparatus 1 has a main frame 2 with two shuttle booms 3 guided therein. The main frame 2 consists of steel and has an essentially parallelepiped outside contour. Openings are provided at the longitudinal-side ends of the main frame 2, into which the shuttle booms 3 are inserted. The shuttle booms 3 exit at opposite-arranged longitudinal-side ends of the main frame 2 and can be displaced in longitudinal direction of the main frame 2.







two opposite-arranged side walls of the main chamber. The crossbeams 4 for the second shuttle boom 3, of which the back is shown in Figure 3, extend inside the two remaining main compartments 12' with a side offset to the crossbeams 4 of the first shuttle boom 3. The energy-supply rods 5 for the shuttle booms 3 extend inside bores 13 of a transverse girder 14 for the main frame 2, one of which is shown in Figure 3.

[50] The shuttle booms 3 are guided with roller bearings inside the individual slide-in compartments 12, 12'. The roller bearings comprise several rollers 15, 16, 17, 18 that are arranged at the individual crossbeams 4 of shuttle booms 3 and at the respective slide-in compartments 12, 12'. The rollers 15, 16, 17, 18 are made of polypropylene, rigid expanded polyurethane or metal and are preferably positioned on springs. The arrangement of rollers 15, 16, 17, 18 is identical for all slide-in compartments 12, 12' and the crossbeams 4 extending therein.

[51] Figure 4 schematically shows the arrangement of a first, second and third roller 15, 16, 17 for guiding a crossbeam 4 inside a slide-in compartment 12, 12'.

[52] The first roller 15 and the second roller 16 are arranged on the back of the crossbeam 4. For this, the roller 15 is arranged on the top surface of crossbeam 4, such that it projects somewhat over the level top surface and rolls off the facing inside wall of the crossbeam 4. The second roller 16 is arranged correspondingly on the bottom of crossbeam 4.

[53] A third roller 17 is installed in the output region of the main frame 2, such that it rolls off the underside of crossbeam 4.

[54] Buffer plates 19, 19' are provided on the inside walls of the corresponding slide-in compartment 12, 12', positioned opposite the top of crossbeam 4, which plates

support the crossbeam 4 inside a slide-in compartment 12, 12'. The first buffer plate 19 is positioned opposite the third roller 17 while the second buffer plate 19' is positioned directly in front of the first roller 15. The buffer plates 19, 19' project from the inside wall of the slide-in compartment 12, 12', wherein their structural heights are adapted to the structural height and installation position of the first roller 15, so that this roller can roll off the inside wall of slide-in compartment 12, 12'. The buffer plates 19, 19' prevent a tilting of the crossbeams 4 inside the slide-in compartment 12, 12', particularly during the displacement movement of crossbeam 4 and the lifting of the container.

[55] The rollers 15, 16, 17 shown in Figure 4 respectively have rotational axes extending in horizontal direction and crosswise to the longitudinal axis of the shuttle boom 3. The rollers 15, 16, 17 in this case extend nearly over the complete width of the crossbeam 4.

[56] The positioning of rollers 15, 16, 17 is shown in further detail in Figure 3.

[57] The first and second roller 15, 16 on the back of the crossbeams 4 of one of the shuttle booms 3 respectively are mounted with a roller bracket 20 on the underside and the top of crossbeam 4. The rollers 15, 16 in this case are always attached with a holder 21 to the roller bracket 20, so that a slight gap remains between the respective roller 15, 16 and the roller bracket 20. Each roller bracket 20 in turn is positioned on a spring 22, wherein the springs 22 sit on a joint support plate 23. The springs 22 are preferably spiral compression springs or silent blocks.

[58] The third roller 17 is also spring-positioned. The third roller 17 is located at the output for the slide-in compartment 12, 12', wherein the roller 17 is positioned on the underside of slide-in compartment 12, 12' in such a way that it projects slightly

upward over the inside wall of slide-in compartment 12, 12'. The third roller 17 in this case sits on a plastic spring buffer 24.

[59] Slots that are not shown herein are preferably inserted into the undersides of slide-in compartments 12, 12' and the spring buffers 24 to allow dirt and water to escape through these slots from the respective slide-in compartment 12, 12'.

[60] With the aid of the first, second and third rollers 15, 16, 17, the undersides and tops of crossbeams 4 of shuttle booms 3 are guided inside the respective slide-in compartment 12, 12'. Additional rollers 18 are provided for a side guidance of crossbeams 4, which rollers project from the side walls of the slide-in compartments 12, 12', as shown in Figure 3. These rollers 18 can also be spring-positioned.

[61] Figure 5 shows the free end of a shuttle boom 3 with a headpiece 6 attached thereto. The headpiece 6 in this case is glued to the shuttle boom 3 with a special glue having a strong shock-absorbing effect. A plastic lining or the like 25 is applied between the front of shuttle boom 3 and the inside of the headpiece 6. A holder part for a locking pin 7 that is not shown in Figure 5 is located on the underside of the headpiece 6. The top of the holder part has a shoulder 26, at a distance to the underside of shuttle boom 3. An additional layer of plastic or the like 27 is inserted into the space between the shoulder 26 and the shuttle boom 3, which layer serves as buffer for cushioning the impact stresses when the headpieces 6 are placed onto the container. Plastic bearings 28 at the shuttle boom 3 serve to further dampen the impact.

[62] The top of headpiece 6 is provided with a projection 29 that points downward and engages in a recess 42? at the shuttle boom 3. The projection can be used to secure the headpiece 6 mechanically to the shuttle boom 3.

[65] To cushion impacts, a buffer 35 is provided between a vertically extending holder 33 and a solid steel plate 34 on the side of the locking pin 7. The buffer 35 consists of a sandwich structure of steel plates and plastic plates.

[67] Figures 9 – 11 show exemplary embodiments of the lifting apparatus 1, which were originally disclosed in DE 101 19 273.

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lifting apparatus 1 in particular has two shuttle booms 3, arranged displaceable on a main frame 2. The shuttle booms 3 are respectively provided with two parallel extending crossbeams 4. Each crossbeam 4 in this case is guided inside a separate slide-in compartment 12, 12' of the main frame 2. Each shuttle boom 3 in turn is provided with an energy-supply rod 5 that extends between the crossbeams 4.

[69] The headpieces 6 adjoin the longitudinal-side free ends of the shuttle booms 3 and have longitudinal axes that are positioned crosswise to the axes for the crossbeams 4 of shuttle booms 3. The casing 8 with the locking pins 7 and the corner guides 9 are located at the ends of the headpieces 6.

[70] Linear drives 37 are provided for realizing the displacement movement of the shuttle booms 3, wherein each linear drive 37 consist of a primary component 38 and a secondary component 39. Figure 9 shows that a separate linear drive 37 is provided for each crossbeam 4 of the shuttle booms 3. The primary component 38 of a linear drive 37 is mounted stationary on the respective slide-in compartment 12, 12' of main frame 2. The secondary component 39 of the respective linear drive 37 is mounted on the crossbeam 4 that extends inside the respective slide-in compartment 12, 12'.

[71] The primary component 38 is provided with means for generating a magnetic field of traveling waves. The secondary component 39 consists of a metal rail, in particular an aluminum rail. This rail extends in longitudinal direction of the crossbeam 4, preferably over its total length.

[72] The secondary component 39 is mounted on the crossbeam 4, such that it is at a constant, predetermined distance to the primary component 38 of the respective linear drive 37. In particular the roller bearings are used for this purpose and ensure that





[78] Figure 10 shows a first arrangement of linear drives 37 at the crossbeams 4 of shuttle booms 3 for the lifting apparatus 1. The crossbeams 4 of the shuttle booms 3, which consist of steel in the present case, have a box-shaped design with a rectangular cross section. The cross sections for the inside spaces of the slide-in compartments 12, 12' are adapted to the cross sections of the crossbeams 4 guided therein, so that the crossbeams 4 are guided with little play inside the respective slide-in compartments 12, 12'. For this, the crossbeams 4 are guided with roller bearings, as shown for the embodiments in Figures 1 – 8. This ensures that the outside walls of the crossbeams 4 extend respectively at a constant distance to the inside walls of the associated slide-in compartments 12, 12'.

[79] The primary components 38 for the linear drives 37 are respectively inserted into a recess 42 of the corresponding slide-in compartment 12, 12', so that the level top surface of the primary component 38 is flush with the surface of the adjacent inside wall of the respective slide-in compartment 12, 12'.

[80] The secondary components 39 of linear drives 37 are respectively formed by metal rails, which are attached to the side wall of a crossbeam 4 that is facing the primary component 38. The top surface of a rail of this type preferably is flush with the top surface of the adjacent side wall of crossbeam 4. The primary components 38 and the opposite-arranged secondary components 39 preferably have identical structural heights.

[81] Figure 11 shows a second arrangement of linear drives 37 at the crossbeams 4 of shuttle booms 3 for the lifting apparatus 1. The slide-in compartments 12, 12' again have a rectangular cross section, analog to the exemplary embodiment

according to Figure 10. The hollow spaces in the slide-in compartments 12, 12', inside of which the crossbeams 4 are guided, in particular have a rectangular cross section.

[82] The crossbeams 4 of shuttle booms 3 have an H-shaped cross section and are made of carbon-fiber compound materials in the present case.

[83] Each crossbeam 4 consists of a support element 4a and two guide elements 4b, each having a rectangular cross section. The support element 4a extends nearly over the complete height of the cavity for the respective slide-in compartment 12, 12', wherein its width is considerably smaller than the width of slide-in compartment 12, 12'. The flat side walls of the support elements 4a thus are at a distance to the side walls of the respective slide-in compartment 12, 12'. For this, the side walls of the support elements 4a extend in vertical planes, parallel to the side walls of the slide-in compartments 12, 12'. Resting on the upper and lower edge of the support element 4a is a separate guide element 4b, which is positioned in a horizontal plane and projects symmetrically over the side walls of the support element 4a. The top surface and the side surfaces of the upper guide element 4b are positioned at a short, constant distance to the inside walls of the slide-in compartments 12, 12'. In the same way, the underside and the side surfaces of the lower guide element 4b are positioned at a short, constant distance to the inside walls of the slide-in compartment 12, 12'. The guide elements 4b function to guide the crossbeam 4 inside the slide-in compartment 12, 12', with the aid of the roller bearings described for the embodiments according to Figures 1 – 8.

[84] With the exemplary embodiment according to Figure 11, the primary components 38 of linear drives 37 are respectively attached to the inside of a side wall for the slide-in compartment 12, 12'. The secondary components 39 of linear drives 37,

which are designed as metal rails, are respectively attached to the side surfaces facing the primary component 38 of the support element 4a of the respective crossbeam 4.

[85] Figure 11 shows that roller spacers 43, which are components of the roller bearings, are provided to keep each secondary component 39 at a constant distance to the primary component 38. The roller spacers 43 have holding brackets that are attached to the primary components 38 and have rollers mounted on the underside, which roll off the side wall of the support element 4a.

[86] Figures 12 - 15 show exemplary embodiments of the lifting apparatus 1 according to the invention, originally disclosed in DE 101 40 449.

[87] Figures 12 and 13 show a lifting apparatus 1 with a design that essentially corresponds to the lifting apparatus 1 design in Figures 1 and 2. In particular, the lifting apparatus 1 again has two shuttle booms 3, arranged displaceable on a main frame 2, wherein the shuttle booms 3 have respectively two parallel-extending crossbeams 4. Each crossbeam 4 is guided inside a separate slide-in compartment 12 or 12' of the main frame 2. Each of the shuttle booms 3 in turn is provided with an energy-supply rod 5 that extends between the crossbeams 4 and serves as push rod.

[88] The free longitudinal-side ends of the shuttle booms 3 are adjoined by head pieces 6, the longitudinal axes of which extend crosswise to the longitudinal axes of crossbeams 4 for shuttle booms 3. The casings 8 with the locking pins 7 and the corner guides 9, not shown in detail herein, are located at the ends of headpieces 6.

[89] Two drum motors 44 are provided for carrying out the displacement movement of a shuttle boom 3, wherein each motor has an electrically driven, essentially cylindrical drum 45.

- [90] Each drum 45 in this case is positioned on a drive shaft 46.
- [91] The symmetry axes for drums 45, in which the respective drive shaft 46 extends, run crosswise to the longitudinal direction of the associated energy-supply rod 5. The drum motors 44 are thus arranged opposite each other on both sides of the energy-supply rod 5.
- [92] The energy-supply rod 5 has a rectangular cross section. The drum 45 of the first drum motor 44 rests against the top surface while the drum 45 of the second drum motor 44 rests against the underside of the energy-supply rod 5. The drums 45 are pushed against the energy-supply rod 5 with predetermined spring tension generated by a spring that is not shown herein. The drums 45 of drum motors 44 rotate in opposite directions and roll off the surfaces of the energy-supply rod 5, so that the shuttle boom 3 is displaced in longitudinal direction owing to the rotational movement of the drums 45.
- [93] It is essential that sufficiently high frictional forces are effective between the surfaces of drums 45 and the energy-supply rod 5 surface, so that the rotational movement of the drums 45 is converted without slippage to a translational movement of the energy-supply rod 5.
- [94] The outer surfaces of drums 45 are provided with a friction lining that is not shown herein. The friction lining consists of a wear-resistant rubber material or a glass-fiber containing plastic casting compound.
- [95] The top surface and the underside of the energy-supply rod 5 are also coated with a wear-resistant and friction lining that is not shown herein.
- [96] Figure 14 shows a shuttle boom 3 guided inside the main frame 2 for the lifting apparatus 1, wherein the side walls of this shuttle boom have a lattice-type design,

consisting of horizontal, vertical and slanted stays 47. Owing to the cavities between the stays 47, this shuttle boom 3 has a particularly low inherent weight. The arrangement of the stays 47 in accordance with Figure 14 additionally results in high stability.

[97] The advantages of the shuttle boom 3 are increased by the fact that the shuttle boom 3 consists of an especially dense material that is nevertheless capable of bearing heavy loads.

[98] In particular, the shuttle boom 3 can consist of or at least in part of glass fiber materials or carbon-fiber compound materials. It is particularly advantageous if shuttle boom 3 elements subjected to tensile loads are made from glass fiber material while shuttle boom 3 elements subjected to pressure loads are made from carbon-fiber compound materials. A particularly high stability and load capacity of the shuttle boom 3 can be achieved in this way.

[99] The shuttle boom 3 of one particularly advantageous embodiment of the invention is manufactured in a hybrid sandwich-style construction. In that case, the elements of shuttle boom 3 consist of several layers of glass fiber materials or carbon fiber compound materials.

[100] Figure 15 shows a detail of a crossbeam 4 for a shuttle boom 3, which is guided inside a slide-in compartment 12 of the main frame 2. A roller bearing is positioned on the underside of slide-in compartment 12, which functions to guide the crossbeam 4 in the slide-in compartment 12.

[101] The roller bearing comprises rollers 15, 16, 17, 18 that are positioned inside roller blocks 48, wherein a roller 16 positioned inside a roller block 48 is shown in Figure 15. The roller 16 is positioned inside the roller block 48 such that it can be

displaced in vertical direction. The underside of crossbeam 4 of shuttle boom 3 rests on the roller 16.

[102] A spring system is assigned to the roller 16, which essentially consists of a spring leaf 49 that is positioned on the side in spring retainers 50. The spring leaf 49 preferably is made of steel and extends in horizontal direction. The spring retainers 50 extend in vertical direction and project downward from the underside of the slide-in compartment 12. An extension 51 is provided on the top of spring leaf 49, which is located directly below the roller 16.

[103] During a load engagement of the shuttle boom 3, particularly if the shuttle boom 3 moves downward with a jerky movement, the roller 16 is pushed downward inside the roller block 48. The spring system dampens and limits the movement. In the process, the roller 16 pushes against the extension 51, so that the spring leaf 49 is somewhat bent through in downward direction, as shown with dashed lines in Figure 15.

[104] A flat support element 52 is respectively provided on the inside walls on the top and bottom of the slide-in compartment 12. The support elements 52 are arranged opposite each other, wherein the lower support element 52 is located in the area of the roller bearing. The support elements 52 serve to better guide the crossbeam 4 inside the slide-in compartment 12, wherein the surfaces of the crossbeams 4 rest on the support elements. The support elements 52 preferably are made of plastic, in particular polyethylene.

List of Reference Numbers:

- (1) lifting apparatus
- (2) main frame
- (3) shuttle boom
- (4) crossbeam
- (4a) support element
- (4b) guide element
- (5) energy supply rod
- (6) head piece
- (7) locking pin
- (8) casing
- (9) corner guide
- (10) electric motor
- (11) toothed belt
- (12) slide-in compartment
- (12') slide-in compartment
- (13) bore
- (14) transverse girder
- (15) roller
- (16) roller
- (17) roller
- (18) roller
- (19) buffer plate

- (19') buffer plate
- (20) roller block
- (21) holder
- (22) spring
- (23) support plate
- (24) spring buffer
- (25) plastic lining
- (26) shoulder
- (27) plastic lining
- (28) plastic bearing
- (29) projection
- (30) electric motor
- (31) head piece – push rod
- (32) bearing
- (33) holder
- (34) solid-steel plate
- (35) buffer
- (36) planetary gear
- (37) linear drive
- (38) primary component
- (39) secondary component
- (40) brake
- (41) spiral cable



- (42) recess
- (43) roller spacer
- (44) drum motor
- (45) drum
- (46) drive shaft
- (47) stays
- (48) roller block
- (49) spring leaf
- (50) spring retainer
- (51) extension
- (52) support element